

This report presents magnetic models of possible structures along five profiles in south-central Alaska. The models were prepared as a preliminary part of the Trans-Alaskan Crustal Transect (TACT) program of the U.S. Geological Survey. The object of TACT is to make coordinated geological, geoelectrical, aeromagnetic, gravity, seismic-refraction, and seismicreflection studies across Alaska from the actively subducting Pacific margin of the continent to its passive Arctic margin. The TACT route will approximately follow the course of the Alyeska pipeline corridor. TACT studies began in summer, 1984, and are scheduled to take five years for completion. I first presented these magnetic profiles at a meeting of the Cordillerian Section of the Geological Society of America in Anchorage, Alaska, on June 1, 1984. They are preliminary and surely will be modified as seismicrefraction data and other information become available from the TACT program and from other sources. Map A shows the location of the five magnetic

profiles on a topographic base. It also shows locations of those 1984 and 1985 TACT seismicrefraction shots that were done in the study area. Figure 1 shows tectonostratigraphic terranes of south-central Alaska, as originally defined by Jones and others (1981). A tectonostratigraphic terrane is a fault-bounded geologic entity having a geologic history, as evidenced by stratigraphy or metamorphic character, that differs from that of surrounding terranes. The delineation of terrane boundaries and working out of the implications of the terrane concept are currently active areas in geology (for example, Schermer and others, 1984). Note that the Copper River basin, the Wrangell volcanoes, and the surrounding portions of the Chugach Range, on the south, and the Alaska Range, on the north, make up the Peninsular terrane (P) and the Wrangellia terrane (W).

The aeromagnetic character of terranes in southern Alaska was described by Griscom and Case (1982). The aeromagnetic map of the Copper River basin was discussed by Andreason and others (1964), that of the Nabesna quadrangle by Griscom (1975), that of the Tanacross quadrangle by Griscom (1976), that of the McCarthy quadrangle by Case and MacKevett (1976), and that of the Talkeetna Mountains quadrangle by Csejtey amd Griscom (1978).

Godson (1984) produced a colored map of compiled (smoothed and re-contoured) aeromagnetic data for Alaska. That map shows a zone of high magnetic field that corresponds approximately to the Peninsular and Wrangellia terranes. The northern boundary of the zone of high magnetic field lies along particular faults of the Alaska Range: the Talkeetna-Broxon Gulch thrusts on the northwest, a part of the Denali fault on the north, and the Totschunda fault on the northeast. Except for the Talkeetna thrust, which is inside Wrangellia as presently defined, these faults all bound Wrangellia. The Peninsular terrane has smooth, high magnetic fields over most of its central part, but contains a buffer zone of magnetic lows some tens of kilometers wide along its southern (and possibly also its northern) border. Speaking generally, however, the rocks of Peninsular and Wrangellia terranes are clearly more magnetic than those of surrounding terranes. The models in this report focus on the magnetic nature of the Peninsular and Wrangellia terranes and their borders. The modeling was done using fields taken from the original aeromagnetic maps (see "Index Showing Sources of Data"). Map B shows a mosaic aeromagnetic map (original maps reduced to the same scale and fitted together without change) of the part of south-central Alaska whence the profiles come. The character and quality of the original data may be

judged from map B.

Figures 2-6 show the models of magnetic structures along profiles $\underline{A-A'}$, $\underline{B-B'-B''}$, $\underline{C-C'-C''}$, $\underline{D-D'}$, and $\underline{E-C'}$. These figures were made using a program for the Hewlett-Packard model 85 desktop computer (Campbell, 1983). The lower part of each figure is a section view showing assumed magnetic structures, and the upper part is a plot showing the observed magnetic field and the calculated magnetic field that results from these structures. There is no vertical exaggeration. The fields are calculated on a datum (dashed line) at the nominal position of the survey aircraft. This datum typically drapes topography at 0.30 km. All bodies are presumed to be magnetized in the direction of the Earth's present-day field. This field differs slightly from profile to profile, but has approximately 56,400 nT magnitude, 76° inclination, and 28° easterly declination everywhere. The effective magnetic susceptibility used for each body is listed in table 1 and is indicated on the figure by using darker shading for higher susceptibilities. Unshaded parts of the section represent nonmagnetic (very low susceptibility) rocks. For some bodies, the magnetic susceptibility that was assigned may be an "effective" one, including both an induced ("true" susceptibility) component and an additional viscous natural remanent magnetization (NRM) component that is assumed parallel to the Earth's present field.

The calculations assume the bodies shown here extend unchanged perpendicular to the plane of the section for varying strike-length distances Y1 and Y2 (table 1), where they are vertically cut off (the "2 1/2-dimensional geometry" of Shuey and Pasquale, 1973). The strike lengths were chosen to match strike extents of corresponding anomalies on map B. Contacts shown in these sections are thought to be correct within 20° of dip, at least near the surface. Errors in attitude modeling can be caused by using incorrect strike lengths, by differences in shape from the idealized prism supposed by the program, by nonuniform susceptibilities of source bodies, and by deviation of survey aircraft from the assumed position. Details of the bodies at depth are not well controlled by the modeling process, and their bottoms could well be half as deep or twice as deep as is shown. Except where I can infer otherwise (as in profile A-A', below), I suppose the base of all deep bodies in the models to be located at 10 km below sea level. This originally was an arbitrary assumption on my part, but later interpretations of refraction seismic profiles done for TACT (Fuis and others, 1985) show that structures under at least the Chugach and Peninsular terranes actually are cut off at about that

PROFILE A-A'

Figure 2 shows two very different ways to model bodies 3 and 4 along profile A-A', which is discussed in more detail by Campbell and Nokleberg (1985). Body 4 represents the Gakona Glacier batholith (formerly the Gulkana batholith of Campbell and Nokleberg, 1985), an intrusive body located between 35 km and 38 km distance on the horizontal scale. In figure 2(a), body 4 is taken to be unrooted, a shallow lacolithic shape having flaring sides. In figure 2(b), body 4 is deeply rooted (its bottom is put at -40 km, the maximum likely Curie depth in the area) and has steep sides. Both models fit the observed magnetic fields equally well. Figure 2 demonstrates the well-known "ambiguity principle" of potential-field modeling (see, for

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Geological Survey.

example, Dobrin, 1976, p. 458-463, 554-555). Any model body we find is merely one of a family of model bodies, all of which give rise to magnetic fields that fit the observed magnetic fields equally well. Figures 2(a) and 2(b) show approximate end members of the family of possible bodies 4. There are many other possible bodies 4. Similarly, there are many possible bodies and combinations of bodies besides the ones shown in figures 2-6 that would match the observed magnetic fields as well as those shown. The magnetic models presented in this report are thought to be consistent with known geology and with each other, but not enough is known yet to adequately constrain all their shapes. Such constraints may become available as companion TACT studies are completed. Meanwhile, these models may serve as preliminary interpretations to be

verified or altered. In the case of profile $\underline{A-A'}$, there are constraints to help choose between the extremes represented by bodies 4(a) and 4(b). These are (1) that body 4, the Gakona Glacier batholith, is known from geologic and aeromagnetic evidence to be truncated by the Denali fault and (2) that the Denali fault is nearly vertical in this area (Nokleberg and others, 1985). Hence the real Gakona Glacier batholith must have a shape more like body 4 in figure 2(b) than that in figure 2(a). This shape in turn suggests that there may be other deep-seated plutons in the Wrangellia terrane. We do not know yet whether Wrangellia is a "thin-skin" terrane——a fairly shallow accreted slice overlying other terranes deeper in the crust-or a "microplate" terrane having its own deep crustal roots. If Wrangellia is a thin-skin terrane, the Gakona Glacier batholith may be a rivet attaching it to the deeper

Profile B-B'-B'' (fig. 3) is entirely in the Peninsular terrane. The Border Ranges fault, forming the southern boundary of the Peninsular terrane, is a few tens of kilometers south of point B. The Peninsular terrane has a strip of nonmagnetic rocks a few tens of kilometers wide just inside its southern border. (There is a similar nonmagnetic strip inside its northern border, too.) The southernmost outcrop of magnetic rocks in the Peninsular terrane is a gabbro that crops out near the 10-km coordinate in figure 3 (Burns, 1982, 1983). Body 1 represents this gabbro at its outcrop and has been extended northward under the Copper River basin as a possible magnetic basement that could give rise to the higher magnetic fields in the heart of the Peninsular terrane. This basement is not necessarily composed of gabbro everywhere. Body 2 represents a more magnetic intrusion within the crystalline basement. Near Glennallen (at about 50 km distance on the horizontal scale), drilling by AMOCO Production Company (Robert Shafer, oral commun., 1984) showed the depth to crystalline basement is greater than about 2 km. The magnetic model in figure 3 may be compared with similar modeling by Burns (1982, 1983),

and by Campbell and Barnes (1985).

Profile C-C' (fig. 4) continues northward across the Copper River basin and passes across the (nominal) boundary between Peninsular terrane, to the south, and Wrangellia terrane, to the north. The terrane boundary is obscured by Quaternary alluvium in this part of Alaska and so its location is not well controlled. Body I represents the possible magnetic basement of the Peninsular terrane heartland, as in figure 3. Body 2 represents a "buttress," which is thought to bound the

seismic profile shot by AMOCO Production Company (Robert Shafer, oral commun., 1984) shows that this butressing body abruptly truncates seismic-reflecting horizons of the Copper River basin. AMOCO correlated one of the truncated horizons with the Jurassic Talkeetna Formation, so we know the buttress was emplaced after the Talkeetna Formation was laid down. Like the other bodies shown in these sections, its base was set arbitrarily at 10 km depth; however, it could be much more deeply rooted, like the Gakona Glacier batholith already discussed. A possible outcrop of the buttress rock occurs under the same magnetic high about 70 km west of profile C-C'; this outcrop, sampled by Bela Csejtey, Jr., consists of a high-susceptibility pyroxene hornblende gabbronorite (Nokleberg, written commun., 1986). Structurally, body 2 may represent a fragment of magnetic ocean crust that was caught during accretion of the Peninsular terrane against terranes farther north. Alternately, it may represent a long horst of Peninsular terrane basement formed during Tertiary normal(?) faulting in the Copper River basin. Bodies 3, 4, and 5 represent units within the metamorphic complex of Gulkana River (informal term, Nokleberg and others, 1986). The metamorphic complex of Gulkana River is bounded on the south by the West Fork fault system and on the north by the Paxon Lake fault, and it may be a separate terrane between the Peninsular terrane and Wrangellia. Body 3 represents schistose granitic rocks that are present between the more magnetic units to the south and north. Body 4 represents mafic metavolcanic rocks that form a 75-kmlong, west-trending ridge (locally called the "Alphabet Hills") in the northern Copper River basin. Body 5 represents an intrusive body, probably consisting of metamorphosed gabbro that crops out south of Tangle Lakes. Profile <u>C-C'</u> is discussed in more detail by Campbell and Nokleberg (1986). Profile C'-C'' (fig. 4) was prepared as part of the Alaska Mineral Resource Assessment Program (AMRAP) study of the Mount Hayes quadrangle and is discussed in more detail by Campbell and Nokleberg (1984). Body 6, figure 4, is a very magnetic unit flooring the Amphitheatre syncline, which was identified from sparse outcrops as an olivine or pyroxene cumulate ultramafic rock. Bodies 7 and 8 are the Nikolai Greenstone, metamorphosed basalt that occurs disconformably near the top of the Wrangellia stratigraphic sequence and

Peninsular terrane basement on the north. A reflection

that typifies Wrangellia. Nokleberg and others (1982) divided Wrangellia into the Tangle subterrane, to the south, and the Slana River subterrane, to the north. The two subterranes are divided by the Eureka Creek thrust, represented on figure 5 by the southern boundary of body 9. The Broxon Gulch thrust forms the northern boundary of Wrangellia. Near this profile, a magnetic shear zone,

body 10, seems to mark the Broxon Gulch thrust. Body

Denali fault whose shape is not well controlled by the

ll is a low-susceptibility pluton just north of the

modeling process.

Profile D-D' (fig. 5) passes across an area that had not been surveyed aeromagnetically (see map B). In August 1983, I collected additional aeromagnetic data along the blank part of this profile using a helicopter-borne magnetometer system. Those fields are shown and modeled in figure 5. An aeromagnetic survey of this area was flown subsequently as part of the TACT program (U.S. Geological Survey, 1985). The new data agree well with those shown on the figure. Body 1, figure 5, is the Peninsular terrane basement discussed above, and body 2 is the magnetic

buttress that truncates it to the north. Body 3

represents a very magnetic body, possibly also profile could be in error. Further modeling of the area to the southeast where the Totschunda fault is buttresslike, whose southwestern border is vertical or nearly vertical. This vertical border may represent a better known may help resolve this issue. fault. It lies along a magnetic lineament, herein termed the "Drum lineament," which extends in a straight line from near Mount Drum to a point about 5

km east of Paxson (fig. 1). Relatively higher magnetic

relatively lower ones occur southwest of it for most of

this distance (see U.S. Geological Survey, 1985). This

segment of the Drum lineament is roughly parallel with

Pacific plate (Stevens and others, 1984). The northern

half of the Drum lineament as defined above is marked

also by a broad relative gravity high of about 20 mGal

amplitude (see Barnes, 1977). South of Mount Drum the

Drum lineament may continue in a relatively straight

it may swing to the southeast, following a strong

either continues in a straight line through Isabel

and others (1982). If the latter is the case, the

between the Tangle and Slana River subterranes of

line to join with the Taral fault (Winkler and others,

1980) in the Valdez 1° X 3° quadrangle, or alternately

gravity gradient that marks the southern border of the

Wrangell Mountains. North of Paxon, the Drum lineament

Pass, or alternately it may swing to the northwest and

west to merge with the Eureka Creek thrust of Nokleberg

Wrangellia (Nokleberg and others, 1982). I believe the

northern end of the Drum lineament marks the boundary

Drum lineament represents a strike-slip fault system

that is an important tectonic element in south-central

Bodies 3, 4, and 5 (fig. 5) probably represent

magnetic intrusive rocks of the Slana River subterrane

of Wrangellia. None of them has been found to crop out

magnetic fields that characterize bodies 4 and 5 occur

in this part of the Copper River basin. The higher

northeastern corner of the Gulkana quadrangle. The

correspondence here between high magnetic fields and

swampy ground suggests bodies 4 and 5 may be composed

Body 6, figure 5, is very magnetic and probably

represents ultramafic rocks. In 1983 I did field work

in the mountains at its northeastern end, but did not

rocks for body 6 are still unknown. Body 7 represents

find any very magnetic rocks in outcrops; the source

the Ahtell pluton of Richter (1966), a zoned pluton

represents a magnetic body, possibly a pluton, near

Mentasta. Its source rock is unknown. Hornblende

consisting predominantly of quartz monzonite. Body 8

diorite rocks crop out nearby, but were found to have

very low magnetic susceptibility. They can therefore

is easy to model body 8 as being vertically trimmed by

fault marked on the figure as "Totschunda fault" is

Jones and others (1981) designate the region

between the Totschunda and Denali faults as a terrane

practically the only magnetic feature in it (see map

aeromagnetic boundary in this part of south-central

Alaska, separating high fields to the southwest from

magnetically. For an important, presumably vertical,

body 8 very much. Note, however, that near profile I

D' the Totschunda fault is buried under alluvium and,

at any rate, is not well defined there. Thus its

position, and maybe even its existence, under the

strike-slip fault, it appears not to have disrupted

of Jurassic and Cretaceous flysch. This region is

generally nonmagnetic, the high over body 8 being

B). The Totschunda fault marks an important

low ones to the northeast. Nevertheless, the

Totschunda fault is a puzzling feature to model

required by the data.

be discounted as the source rocks for this anomaly. It

the Denali fault, but no particular displacement at the

over swamps south and east of the hills in the

of ultramafic rocks that weather readily.

fields occur northeast of the Drum lineament, and

the edge of a seismicity zone some 70 km to the

southwest that is associated with the subducting

Profile E-E' (fig. 6) has few magnetic features to model. Body 1 (fig. 6) represents the thick sheet of magnetic basement rocks that this report assumes to be the source of the magnetic high over the heartland of the Peninsular terrane. The band of nonmagnetic rocks inside this boundary of the Peninsular terrane is mapped as trondhjemite (Csejtey and others, 1978). Unlike profiles $\underline{C-C'}$ and $\underline{D-D'}$, no magnetic buttress truncates the magnetic Peninsular terrane basement here. A possible buttresslike body, body 2, does occur several tens of kilometers farther to the northwest, however. Arguments similar to those given for profile A-A' lead to the conclusions that this buttress must be deeply rooted and that its northwestern edge must be nearly vertical. This edge may represent the Talkeetna thrust, which, like the Totschunda fault, marks a boundary between regions of higher and lower aeromagnetic fields (see map B). If so, however, the Talkeetna thrust must be nearly vertical here, rather than dipping at shallow angles to the southeast as Csejtey and others (1982) have inferred from geologic evidence. Thus the Talkeetna fault, like the Totschunda fault, presents a puzzle for magnetic modeling.

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represented

Gakona Glacier batholith

Gakona Glacier batholith

Ultramafic units

Ultramafic units

Peninsular terrane

Peninsular terrane

Ultramafic buttress

Ultramafic rocks of

Nikolai Greenstone

Nikolai Greenstone

Wrangellia: Slana

Pluton north of df

Peninsular terrane

Ultramafic buttress

Ultramafic platform

Ultramafic platform

Ultramafic platform

Pluton near Mentasta

Peninsular terrane

Wrangellia pluton

Eureka buttress

Ahtell pluton

Intrusive body

Schistose body in GRC

Metavolcanic body in GRO

Amphitheatre syncline

Magnetic zone along bgt

Basement pluton

basement

susceptibility

(c.g.s.)

.0015

.0022

.0035

.0015

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